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Growth and Vigor Information in Thinned Second-Growth Ponderosa Pine Stands on the Deschutes and Ochoco National Forests

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GROWTH AND VIGOR INFORMATION IN THINNED SECOND-GROWTH PONDEROSA PINE STANDS ON THE DESCHUTES AND OCHOCO NATIONAL FORESTS

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INTRODUCTION

Over the past 25 years, thousands of acres of second-growth ponderosa pine stands in eastern Oregon and Washington have been thinned. During this time, spacing guidelines have increased from 8X8 ft. to 15X15 ft. or greater. One of the reasons for increasing the spacing has been to prevent mountain pine beetle outbreaks. Studies by Sartwell and Stevens (1975) and Sartwell and Dolph (1976) showed that potential for mountain pine beetle infestation is minimized by reducing stem basal area to less than 100 square feet per acre.

Precommerical thinning guidelines originally prohibited cutting trees larger than 5 inches DBH during thinning. This restriction was imposed because it was felt that trees of this size could be utilized as pulpwood during the next entry. Due to this restriction, proper stocking density was not always achieved and portions of many stands remained overstocked. Although stocking is greater than what is really desirable in these stands, thinning has protected them from bark beetle activity, at least temporarily.

The question now is, "How much longer will thinned stands with narrow spacings remain free of beetle activity?" The first observation of mountain pine beetles infesting a previously thinned stand was reported in 1981 on the Paisley Ranger District, Fremont National Forest. The stand was thinned to 8X8 ft. spacing 22 years ago. When infestation occurred, basal area was high, varying from 180 to 200 square feet per acre, and average tree diameter at breast height was 10 inches. Dominant trees were about 12 inches DBH. The beetles were attacking the larger dominant trees in the same fashion observed in unmanaged stands. Since there is so little information available on how long managed second-growth ponderosa pine stands with 8x8 ft. spacing will remain free of mountain pine beetle activity, it is necessary to start comparing beetle activity in such stands with that in units with wider spacing. The results of the first efforts are discussed in this report.

An evaluation of four second-growth ponderosa pine stands on the Fort Rock District, Deschutes National Forest and 14 stands on the Ochoco National Forest was made in June 1982.

SITE DESCRIPTION

Deschutes National Forest

The second-growth ponderosa pine stands on the northern portion of the Fort Rock District are essentially even-aged as a result of widespread railroad logging done some 60 years ago. Precommercial thinning began in the late 1950's and commercial thinnings have been done on selected sites since the late 1970's. The legal description and stand history of four stands sampled in this evaluation are as follows:

Stand	Legal Description	Kind of Thinning	Thinning Date	Spacings
1	T. 20 S., R. 11 E., sec. 2	Precommercial	1967	12x12 ft.
2	T. 19 S., R. 11 E., sec. 13	Precommercial	1962	8x8 ft.
3	T. 19 S., R. 12 E., sec. 15	Commercial	1978	17x17 ft.
4	T. 19 S., R. 12 E., sec. 30	Commercial	1981	16x16 ft.

Ochoco National Forest

Four stands were examined on the Paulina and Big Summit Districts. Three stands each were examined on the Prineville and Snow Mountain Districts. The location and stand history of the 14 stands are as follows:

Stand	Legal Description	Kind of Thinning	Thinning Date	Spacings
1	T. 18 S., R. 19 E., sec. 1	Precommercial	1965	12x12 ft.
2	T. 18 S., R. 19 E., sec. 14	Precommercial	1964	10x10 ft.
3[1/]	T. 18 S., R. 20 E., sec. 9	Precommercial	1957	8x8 ft.
4	T. 15 S., R. 24 E., sec. 26	Precommercial	1965	10x10 ft.
5	T. 15 S., R. 24 E., sec. 27	Precommercial	1957	8x8 ft.
6	T. 15 S., R. 23 E., sec. 1	Precommercial	1981	17x17 ft.
7	T. 15 S., R. 24 E., sec. 20	Precommercial	1960's?	8x8 ft.
8	T. 13 S., R. 19 E., sec. 34	Precommercial	1960's?	8x8 ft.
9[2/]	T. 15 S., R. 21 E., sec. 6	Precommercial	1962	10x10 ft.
		Commercial	1981	20x20 ft.
10	T. 14 S., R. 22 E., sec. 18	Precommercial	1960's?	8x8 ft.
11	T. 13 S., R. 21 E., sec. 32	Precommercial	1960's?	10x10 ft.
12	T. 19 S., R. 25 E., sec. 34	Precommercial	1960's?	12x12 ft.
13	T. 20 S., R. 25 E., sec. 4	Precommercial	1960's?	12x12 ft.
14	T. 21 S., R. 25 E., sec. 29	Precommercial	1950's?	8x8 ft.

1/ Mountain pine beetle activity (2 to 3 years old), observed but no current activity.

2/ Overstory removed in 1981 after-logging stocking was reduced to approximately 20x20 spacing.

Stand numbers listed refer only to this examination, and have no relationship to Forest or District management designations.

METHODS

A total of 15 sample points was established in each stand on a two by two chain grid. Basal area was measured using a 10 BAF prism. At each sample point, the diameter of the dominant tree nearest the point center was measured and two increment cores were taken with an increment hammer. The width of the 1981 growth ring was measured and averaged for the two samples taken from each tree. No measurement of the sapwood thickness was made. For our calculations, we assumed that 90% of the total stem basal area is sapwood.

Tree/stand vigor was determined by using the technique developed by Larrson et al (1982), Waring and Pitman (1980), and Waring et al (1980). Their technique estimates tree vigor based on the ratio of current weight of stem growth to the area of crown leaf surface. The latter is estimated from the sapwood area at breast height (Grier and Waring 1974) based on the following: One cm^2 of sapwood is equal to 0.11 m^2 of projected leaf area (R. H. Waring, P. Schroder, and R. Oren, manuscript in review). Calculations were made in the field using a HP-41 CV programmable calculator.

Stand basal area analysis was done by comparing our results with the maximum value of 150 sq. ft./acre Sartwell and Stevens (1975) considered as hazardous for mountain pine beetle.

Stand vigor analysis was done by comparing our results to the lodgepole pine vigor classification recommended by Waring and Pitman (1980). They suggested the following indices:

1. If growth is calculated to be less than 50 grams of wood produced per square meter of foliage, the stand/tree is highly susceptible to beetle infestation and classified as low vigor.

2. If growth is calculated to be between 50 and 100 grams of wood produced per square meter of foliage, the stand/tree is moderately susceptible to beetle infestation.

3. If growth is calculated to be greater than 100 grams of wood produced per square meter of foliage, the stand/tree has a low susceptibility to beetle infestation and is classed as high vigor.

Regarding the question, "How much longer will thinned stands remain free of beetle infestation?", my approach is to estimate vigor by calculating the percent increase in stem basal area for the next 10 years. The approach is based on the assumption that trees will maintain the same growth rate during the next 10-year period as that measured for 1981. All calculations will be based on stand averages of the dominant trees. Individual tree basal area was obtained from Dilworth's (1976) table for the average tree diameters measured in 1982 and the projected average diameter expected in 10 years. These values were multiplied by the stand average number of trees per sample point as measured using a 10 BAF prism. The average point basal area was divided by the projected basal area to calculate the percent change in basal area for the 10-year period. This was applied to the existing basal area per stand to project the estimated increase that could occur in the next 10 years. The results were compared to the 150 sq. ft. stem basal area criteria to determine if the stands will be susceptible to beetle attack in 1991.

RESULTS

Based on stand averages, no stand was now producing less than 50 grams of wood per square meter of foliage (Table 1). No stand had an average stem basal area above 150 sq. ft. per acre. No current mountain pine beetle activity was observed in any of the stands. Beetle-caused mortality was noted in only one stand and the condition of the dead trees indicated that the beetles had attacked them 2 or 3 years previous to 1981.

The average amount of wood produced per square meter of foliage in 1981 ranged from 67 to 144 grams. Five stands had produced more than 100 grams of wood, the level considered to be least susceptible to mountain pine beetle. None of the stands with 8-foot spacing were in this group. Most of the stands with 8-foot spacings produced less wood during the 1981 growing season than stands with wider spacing (Table 2).

Individual trees in 12 of the 18 stands produced less than 50 grams of wood per square meter of foliage. The lowest production measured was 14 grams on a tree in Stand 4 on the Deschutes National Forest (Table 1). The highest wood production measured on an individual tree was 250 grams (in.), Stand 11 on the Ochoco National Forest.

The average stem basal area varied from 70 sq. ft. per acre (20x20 ft. spacing) to 129 sq. ft. per acre (8x8 ft. spacing) (Table 1). Although the average stem basal area for the 18 stands was less than 150 sq. ft./acre, there are 27 individual sample points where the stem basal area exceeded the 150 sq. ft./acre. Most, 16, of these 27 sample points exist in the stands with 8-foot spacing (Table 2). The highest stem basal area recorded was 230 sq. ft./acre in Stand 2 on Deschutes National Forest (Table 1).

Increment growth during the 1981 growing season was good to excellent in 17 of the 18 stands. The average width of the 1981 growth ring ranged from 3.1 mm to 1.1 mm. Assuming the trees would continue to produce the same average thickness for the next 10 years, the number of growth rings per inch would be projected to be from 8 and 23 rings or 25/20ths and 9/20ths per inch, respectively (Table 3). The widest growth ring measured was 5 mm (equal to about 5 rings/inch or 40/20ths per inch). The smallest growth ring measured was 0.3 mm (equal to about 85 rings/inch or 2.35/20ths per inch).

In projecting the average stem basal area expected for the next 10 years to determine if any stand would be highly susceptible to a mountain pine beetle outbreak, two stands, Stands 1 and 2 on the Deschutes National Forest, will meet or exceed the 150 sq. ft./acre hazard level (Table 4). The anticipated increase in stem basal area for the remaining 16 stands would still be below the hazard level of 150 sq. ft. for the next 10 years.

Discussion

My approach of estimating the increase in stem basal area to answer the question of how much longer the older thinned stands with narrow spacings will remain free of mountain pine beetle activity may be too simple to give a definite answer to a most complex problem. Also, my assumption that trees will continue to produce growth rings of equal thickness for the next 10 years is, of course, quite theoretical. Actually, the width of the rings will decrease with each passing year at a rate governed by how fast the stand canopy closes, particularly in stands with 8 to 12 foot spacings. Regardless, this approach does provide a method for predicting beetle risk in a stand within a 10-year period.

Trend predictions are not precise nor is projection of mortality an exact science. Several factors have to be considered when interpreting beetle-forest interactions. The intensive competition between trees at high stand densities and its effect on tree resistance to beetle attack constitute a major factor in outbreak tree killing. Bark beetles are opportunistic and take advantage of situations that we could have prevented through management.

Many environmental factors affect tree growth. The interaction among these factors is complex with no one factor paramount. Recent studies have shown that sunlight is one important factor in overstocked stands. Trees begin to suffer from shading as stands grow and the canopy closes. The slightest competition for sunlight prevents individual trees from growing at optimum rates as evidenced by the narrowing of the annual growth ring. This decrease in growth and vigor is a gradual process. As a rule, bark beetles attack unmanaged stands in which trees have produced 20 or more rings per inch. Thus, thinning exposes the crowns of the residual trees to more sunlight, and at the same time reduces root competition and the competition for soil moisture and nutrients. All this helps trees to become more vigorous and resistant to bark beetle attacks. The degree of resistance is proportional to the extent of the thinning. Heavily thinned stands are more vigorous and less susceptible to beetle activity for longer periods than stands of narrow spacings. Stands on better sites could support higher basal area while maintaining an acceptable growth vigor.

When evaluating imminent hazard from bark beetles, several entomological factors need to be considered: (1) historic evidence of beetle activity in the surrounding area, (2) recent beetle activity in the stand, particularly during the past 3 to 5 years, (3) any major beetle outbreaks near the uninfested area, and (4) trends in beetle population levels.

In view of the factors discussed above, I believe that some of the older thinnings with spacings of 12 feet and less, on the Fort Rock District, Deschutes National Forest, are in danger of bark beetle attack. This belief is based on the following: (1) projected average stem basal area is going to meet or exceed the hazard level of 150 sq. ft. per acre within the next 10 years in two stands, and (2) there is a major mountain pine beetle outbreak in progress in the unmanaged lodgepole pine stands on the District. Within the two stands, there are groups of trees with stem basal areas already exceeding 150 sq. ft. per acre. One basal area measurement of 230 sq. ft. per acre was recorded. Thus, there are portions of these stands that are already susceptible to mountain pine beetle. With the large beetle population present, it is just a matter of time until trees in these dense stands are attacked. Based on past experience gained during the beetle outbreak in northeast Oregon during the 1970's, we can expect the beetles to move into the second-growth ponderosa pine stands after the lodgepole pine stands have been destroyed. In fact, we have evidence that this is already occurring in areas on the District.

Beetle risk in the thinned stands on the Ochoco National Forest is low except for those areas within a stand where the stem basal area exceeds 150 sq. ft. per acre. I do not anticipate any buildup in the beetle population or a prolonged outbreak. I expect the beetles to enter and kill a few trees. Then the population should collapse once the basal area has been reduced similar to the situation observed in Stand 3 in the Maury Mountains on the Prineville District. There is currently no major mountain pine beetle population in or near any of the stands on the Ochoco National Forest.

Although stands thinned to 8 ft. spacing have been free of major mountain pine beetle outbreaks for a minimum of 25 years, there is another management objective involved. In most cases, the primary objective for thinning overstocked second-growth ponderosa pine stands was to increase growth of crop trees. Originally, the premise was that we would reenter these stands in 20 years with a commercial thinning operation. We envisioned that the need for pulpwood would develop by this time and provide the market necessary for utilizing the material. Few, if any, of these older thinned stands have been reentered to maintain proper stocking levels.

If a major mountain pine beetle outbreak were to develop in these previously managed stands, we should expect significant losses to occur, particularly stands thinned to less than 15-foot spacings. Evidence is now accumulating to support this dire prediction.

In 1967, a 250-acre test of thinning a 55-year-old ponderosa pine stand for silvicultural control of the mountain pine beetle was established near Baker, Oregon. Spacing treatments were 12x12, 15x15, 18x18, and 21x21 feet. We have been visiting these plots every 5 years to measure beetle-caused mortality (Sartwell and Dolph 1976). The most recent visit was October 1982, 15 years after treatment. It is noteworthy that between 1976 and 1980, these plots were subjected to one of the largest beetle outbreaks of record in Oregon. Although we have not analyzed the 1982 data, it is obvious that the 12x12 feet plots did not provide adequate protection against the beetles. Little or no mortality was recorded in the 18- and 21-foot spacings. Some mortality was observed in the 15-foot plots but the impact is unknown.

Recommendations

When planning TSI programs, alternatives calling for retreatment of stands thinned to less than 15 feet should be considered. Economic, tree vigor and site potential analyses will help determine priority of retreatment over initial treatment opportunities. The demand for firewood may play a role in the outcome of the analyses.

Table 1.—1981 Growth and vigor in thinned second-growth ponderosa pine stands on the Deschutes and Ochoco National Forests listed from the highest average stand vigor to the lowest average stand vigor.

Forest	Stand No.	Hazard Class	Grams of Wood Produced Per Sq. Meter of Foliage Avg (Range)	Spacing (ft)	Growth Ring Thickness (mm) Avg (Range)	Basal Area (sq. ft.) Avg (Range)	DBH of Dominant Tree (inches) Avg (Range)
O[1/]	9[3/]	↑	144(80-228)	10x10	3.1(2.0-5.0)	70(20-110)	11.0(5.3-16.0)
D[2/]	3[4/]		137(70-216)	17x17	2.9(1.3-4.5)	71(10-130)	11.0(7.7-15.4)
O	1	Low	113(51-177)	12x12	2.3(1.2-3.0)	81(30-130)	10.1(6.7-14.1)
O	11		105(41-250)	10x10	2.4(1.2-4.0)	91(10-170)	14.7(6.3-22.4)
O	4	↓	103(56-145)	10x10	2.1(1.2-2.8)	89(40-140)	10.6(6.8-16.8)
O	13	↑	97(51-193)	12x12	2.0(1.1-3.5)	92(40-130)	10.9(7.6-15.6)
O	10		96(35-152)	8x8	2.0(0.8--2.8)	107(60-200)	11.2(5.6-22.0)
O	12		94(58-167)	12x12	1.9(1.3-3.0)	90(30-190)	10.2(7.6-13.2)
O	7		89(47-129)	8x8	2.1(1.5-3.0)	103(30-170)	13.5(7.3-18.5)
O	2		87(44-144)	10x10	1.7(0.8-3.0)	95(30-140)	9.5(5.9-11.8)
D	4[3/]		87(14-143)	16x16	2.2(0.3-4.1)	89(50-140)	14.2(10.7-18.4)
D	1	Moderate	82(40-152)	12x12	2.0(0.7-4.0)	127(70-190)	12.8(7.0-16.4)
O	5		77(47-106)	8x8	1.7(1.0-2.6)	119(50-180)	11.0(8.9-13.9)
O	6[3/]		77(22-160)	17x17	1.5(0.5-3.2)	92(70-150)	9.8(6.8-12.6)
O	8		77(25-125)	8x8	1.5(0.5-2.5)	91(40-140)	9.6(5.9-12.8)
O	3[5/]		72(39-167)	8x8	1.6(0.7-4.0)	101(30-130)	11.6(7.0-16.8)
O	14		69(31-111)	8x8	1.1(0.5-2.0)	93(60-120)	7.2(4.3-10.1)
D	2	↓	67(27-111)	8x8	1.6(0.6-3.1)	129(60-230)	13.5(10.6-17.4)

1/ Ochoco NF
2/ Deschutes NF
3/ Overstory removed 1981 after logging stocking was reduced to approximately 20x20 ft. spacing in June 1982.
4/ Overstory removed 1978.
5/ Mountain pine beetle-caused tree mortality 2 or 3 years ago, but no current beetle activity.

Table 2.--Number of sample points above and below 150 sq. ft. per acre, the hazard level considered as critical in managing mountain pine beetle in second-growth ponderosa pine stands.

	Forest	Stand No.	Spacing (ft.)	Stem Basal Area: Stand Avg	Stem Basal Area: Nº Sample Points <150 sq. ft./ac.	Stem Basal Area: Nº Sample Points >150 sq. ft. /ac.
1	O[1]	9[3]	10	70	15	0
2	D[2]	3[4]	17	71	15	0
3	O	1	12	81	15	0
4	D	4[3]	16	89	15	0
5	O	4	10	89	15	0
6	O	12	12	90	13	2
7	O	11	10	91	13	2
8	O	8	8	91	14	1
9	O	13	12	92	15	0
10	O	6[3]	17	92	14	1
11	O	14	8	93	15	0
12	O	2	10	95	15	0
13	O	3	8	101	15	0
14	O	7	8	103	13	2
15	O	10	8	107	13	2
16	O	5	8	119	9	6
17	D	1	12	127	9	6
18	D	2	8	129	10	5

1/ Ochoco NF
2/ Deschutes NF
3/ Overstory removed 1981 after-logging stocking was reduced to approximately 20x20 ft. spacings.
4/ Overstory removed 1978.

Table 3.--Thinning stand data on Ochoco and Deschutes National Forests arrayed by average stem basal area from lowest to the highest values and the appropriate number of growth rings per inch based on the stand average thickness of the 1981 growth ring.

Forest	Stand No	Spacing (ft.)	Ave Stem Basal Area (sq. ft.)	Avg Growth Ring Thickness (mm)	Estimated Rings/Inch[1/] (No)	Avg Gm Wood Prod. Per M^2 Foliage
O[2/]	9[4]	20	70	3.1	7	144
D[3/]	3[5/]	17	71	2.9	9	137
O	1	12	81	2.3	11	113
D	4[4/]	16	89	2.2	11-12	87
O	4	10	89	2.1	12	103
O	12	12	90	1.9	13-14	94
O	11	10	91	2.4	10-11	105
O	8	8	91	1.5	17	77
O	13	12	92	2.0	13	97
O	6[4/]	17	92	1.5	17	77
O	14	8	93	1.1	23	69
O	2	10	95	1.7	15	87
O	3[6/]	8	101	1.6	16	72
O	7	8	103	2.1	12	89
O	10	8	107	2.0	13	96
O	5	8	119	1.7	15	77
D	1	12	127	2.0	13	82
D	2	8	129	1.6	16	67

1/ Assumption that trees will continue to produce similar thick growth ring during next 10 years

2/ Ochoco NF

3/ Deschutes NF

4/ Overstory removed 1981, after_logging stocking was reduced to approximately 20x20 spacing

5/ Overstory removed 1978

6/ Mountain pine beetle-caused tree mortality 2 to 3 years ago, but no current beetle activity in June 1982

Table 4.--Projected increase of average stand tree diameter for dominant trees and basal area per acre for the next 10 years (1991).

Forest	Stand Nº	Spacing (ft.)	Avg Width Growth Ring (mm)	DBH/Dominants Today In.	DBH/Dominants In 10 Yrs. In.	Avg Stand Basal Area/Acre Today	Avg Stand Basal Area/Acre In 10 Yrs.
O[1/]	9[3/]	10	3.1	11.0	14.2	70	98
D[2/]	3[4/]	17	2.9	11.0	13.4	71	94
O	1	12	2.3	10.1	12.0	81	104
D	4[3/]	16	2.2	14.2	16.0	89	108
O	4	10	2.1	10.6	12.4	89	113
O	12	12	1.9	10.2	11.8	90	113
O	11	10	2.4	14.7	16.7	91	112
O	8	8	1.5	9.6	10.9	91	111
O	13	12	2.0	10.9	12.5	92	114
O	6[3/]	17	1.5	9.8	11.1	92	112
O	14	8	1.1	7.2	8.0	93	111
O	2	10	1.7	9.5	10.7	95	115
O	3	8	1.6	11.6	12.8	101	119
O	7	8	2.1	13.5	15.3	103	125
O	10	8	2.0	11.2	12.8	107	132
O	5	8	1.7	11.0	12.2	119	142
D	1	12	2.0	12.8	14.4	127	154[5/]
D	2	8	1.6	13.5	14.7	129	150[5/]

1/ Ochoco NF

2/ Deschutes NF

3 Overstory removed 1981, after logging-stocking was reduced to approximately 20x20 ft. spacing

4/ Overstory removed 1978

5/ Stem basal area could, in 10 years, meet or exceed the hazard level of 150 sq. ft./acre.

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